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Thermal combustion engine which converts thermal energy into mechanical energy and use thereof

FIELD OF THE INVENTION

The present invention relates to a thermal combustion engine which converts thermal energy into mechanical energy and the use of such a thermal combustion engine.

BACKGROUND OF THE INVENTION

Multiple thermal combustion engines are known from the related art. Thus, for example, DE 199 48 128 A1 discloses a device and a method for generating flow energy in liquids from heat. In this case, the device comprises a housing having a vapor intake opening connected to a vaporizer and a vapor outlet opening connected to a condenser. Furthermore, the housing has a flow opening connected to a hydromotor and a return connection connected thereto. A rotor is positioned within the housing, which has multiple cells, in each of which pistons are located. By supplying vapor under pressure through the vapor intake opening, removing the vapor from the vapor outlet opening, and rotating the rotor, a hydraulic liquid is pumped through the hydromotor. However, this device has the disadvantage that it has a complex construction and, because of its multicomponent structure, has a large overall volume and may therefore not be implemented compactly. In addition, a pump is required in particular in order to return the liquid condensed in the condenser back to the vaporizer.

Furthermore, US 2002/0194848 A1 discloses a vapor motor for driving a generator. In this case, the vapor motor comprises a rotary engine, which is integrated in a closed vapor loop. The vapor loop comprises a vapor generator, a vapor injector for injecting vapor into the rotary engine, and a condenser for condensing the vapor which exits out of the rotary engine. A combustion is performed within the vapor

motor in order to supply heat to a vapor generator which comprises a bundle of circular pipes. The vapor exiting out of the vapor generator is applied to the rotary engine and subsequently flows through a further bundle of pipes which are used for preheating combustion air. The vapor thus partially cooled is supplied to a condenser, and the water condensed in the condenser is subsequently supplied back to the vapor generator via a pump. However, this vapor motor also has the disadvantages of a complex construction and a lack of compactness because of the multiple components necessary, including a pump for conveying water condensed in the condenser into the vapor generator. Furthermore, the rotary engine is subject to wear, because of which high maintenance costs result.

In addition, thermal combustion engines comprising vapor turbines are known from the related art. Vapor generated in an external vapor generator is supplied to the vapor turbines in such a way that a rotor having a blade wheel, which is positioned in a housing, is driven. After passing through the blade wheel, the vapor coming out of the housing is condensed, and the working medium thus condensed is supplied back to the vapor generator via a pump. However, these vapor turbines have the disadvantage that additional components, particularly valves, control elements, or pumps, are necessary in order to achieve conversion of thermal energy into mechanical energy. In particular, thermal combustion engines of this type, which use a vapor turbine, have a high power to weight ratio, i.e., the weight in relation to the extractable power, because of the large number of individual components.

SUMMARY OF THE INVENTION

As will be recognized from the description herein, embodiments of the present invention provide a thermal combustion engine which overcomes the disadvantages of the related art. In particular, the conversion of thermal energy into mechanical energy is to be attained while achieving a low power to weight ratio, a high efficiency, low pollutant and noise emissions, and a simple, low-maintenance, and low-wear construction.

In one implementation, a thermal combustion engine comprises at least one vapor generation device for at least partially vaporizing a liquid first working medium using thermal energy supplied to the thermal combustion engine, at least one rotor which is

drivable using a vaporized first working medium to generate mechanical energy and is rotatable in relation to at least one stator around at least one axis of rotation, and at least one condensation device for condensing the vaporized first working medium after driving the rotor, the rotor generally completely surrounding the stator, and the rotor generally completely enclosing the vapor generation device and the condensation device.

In another implementation, a thermal combustion engine comprises at least one vapor generation device for at least partially vaporizing a liquid first working medium using thermal energy supplied to the thermal combustion engine, at least one rotor which is drivable using a vaporized first working medium to generate mechanical energy and is rotatable in relation to at least one stator around at least one axis of rotation, and at least one condensation device for condensing the vaporized first working medium after driving the rotor, the rotor at least partially surrounding the stator.

In the foregoing implementations, a centrifugal force may be generated on the liquid first working medium by a rotational movement of the rotor, through which a centrifugal force closure may be implemented between the condensation device and the vapor generation device, and the liquid first working medium is conveyable out of the condensation device into the vapor generation device using the centrifugal force closure.

Further described and claimed herein are various advantageous embodiments and features that may be implemented in connection with the foregoing implementations.

In addition, disclosed herein is the use of a thermal combustion engine according to the present invention as a topping turbine, exhaust vapor turbine, back pressure turbine, extraction turbine, impulse turbine, and/or reaction turbine.

Embodiments of the present invention are based on the surprising recognition that the implementation of a vapor turbine in the form of an external rotor motor, in which a vapor generation device and a condensation device are integrated in the rotor, results in a constructively simpler construction of a thermal combustion engine. In particular, a thermal combustion engine may be provided which dispenses with

control elements and/or impellers, such as valves or pumps for conveying a working medium from a vaporizer to a condenser. Through the integration of a vaporizer and condenser in a rotor which rotates around at least one stator having a blade wheel, automatic conveyance of working medium from the condenser to the vaporizer is achieved via the centrifugal force acting on the working medium through the rotation.

In addition, the rotational movement of the rotor and therefore the centrifugal force acting on the working medium ensures that the working medium itself closes a connection channel running from the condenser to the vaporizer in such a way that vapor generated in the vaporizer may only reach the condenser by exiting the vaporizer, hitting the blade wheel, and therefore causing rotation of the rotor. In particular, the centrifugal force acting on the working medium due to the rotation of the rotor causes a transition of the vaporized working medium from the vapor generator into the condenser to be possible only in the way described above after passing through the blade wheel, even at higher pressures within the vapor generator in relation to the pressure in the condenser, because of the hydrostatic pressure caused by the centrifugal force. This means that a centrifugal force closure between the condenser and the vaporizer is implemented according to the present invention. This centrifugal force closure is also used as a pump for conveying the working medium from the condenser into the vaporizer. This results in additional feed pumps, etc. being able to be dispensed with.

In addition, the construction of the vapor turbine as an external rotor motor achieves a higher efficiency of the thermal combustion engine. Both heating of the machine on the vaporizer side, using combustion gases, for example, and also cooling on the condenser side, using cold air, for example, may be performed using a countercurrent principle according to the present invention, arbitrary flow directions of the cooling and/or heating medium otherwise being possible. Efficient excitation of the combustion gases is achieved in this case in that combustion gases of higher temperature heat the area in proximity to the axis of the rotor and therefore especially hot vapor exits out of the vapor generator, which is then particularly directed onto the blade wheel of the stator via nozzles.

The combustion gases then flow in a radial direction from the axis of rotation of the rotor outward to the external circumference of the rotor, where the cooling combustion gases bring to a boil the liquid working medium, which is located there at the external circumference of the rotor because of centrifugal force. The vapor generated in this case travels in the rotor in the direction of the axis of rotation of the rotor and is continuously heated because of the temperature of the combustion gases, which becomes higher and higher in this direction, so that an isobaric expansion may occur, for example.

On the condenser side, the cooling air flows from the external circumference of the rotor in the radial direction toward the axis of rotation of the rotor, outside the rotor. Thus, vapor which flows radially outward from the axis of rotation in the interior of the rotor is increasingly cooled and condensed. Therefore, the construction of a thermal combustion engine according to the present invention as a vapor turbine in an external rotor motor allows the use of a countercurrent principle both for heating a working liquid and also for cooling it, which results in an increase of the efficiency of the thermal combustion engine.

BRIEF DESCRIPTION OF THE DRAWINGS

Further features and advantages of the present invention result from the following description, in which preferred embodiments of the present invention are explained for exemplary purposes on the basis of schematic figures.

Figure 1 shows a sectional view of a first embodiment of a thermal combustion engine according to the present invention;

Figure 2 shows a sectional view of the thermal combustion engine of Figure 1 along the plane A-A of Figure 1;

Figure 3 shows a sectional view of a second embodiment of a thermal combustion engine according to the present invention;

Figure 4 shows a sectional view of the thermal combustion engine of Figure 3 along the plane B-B of Figure 3;

Figure 5	shows a sectional view of a third embodiment of a thermal combustion engine according to the present invention;
Figure 6	shows a sectional view of the thermal combustion engine of Figure 5 along the plane B-B of Figure 5;
Figure 7	shows a sectional view of a fourth embodiment of a thermal combustion engine according to the present invention;
Figure 8a	shows a sectional view of a fifth embodiment of a thermal combustion engine according to the present invention;
Figure 8b	shows a sectional view of an alteration of the fifth embodiment of a thermal combustion engine according to Figure 8a;
Figure 9	shows a sectional view of a sixth embodiment of a thermal combustion engine according to the present invention;
Figure 10	shows a sectional view of a seventh embodiment of a thermal combustion engine according to the present invention; and
Figure 11	shows a sectional view of an eighth embodiment of a thermal combustion engine according to the present invention.

DETAILED DESCRIPTION

A first embodiment of a thermal combustion engine is illustrated in Figures 1 and 2 in the form of a vapor turbine 1, or rather a compact vapor turbine, having an integrated vapor generation zone. The vapor turbine 1 comprises a stator 3, which in turn comprises a fixed shaft 5 and a blade wheel 7 connected to the shaft 5. A rotor 11 having front walls 11a, 11c and a peripheral wall 11b is mounted so it is rotatable in relation to the stator 3 via a bearing 9 and a seal 10 in such a way that the interior of the rotor 11 is sealed. The rotor 11 essentially comprises a first chamber 13 and a second chamber 15. The chambers 13, 15 are separated from one another by a

thermally insulating wall 17, except for openings 19 of the wall 17 in the area of the peripheral wall 11b of the rotor 11. A working medium 21, preferably water, may flow through the openings 19 from the second chamber 15 into the first chamber 13, as will be described later in detail.

Because of the centrifugal forces acting on the working medium 21 during rotation of the rotor 11, the working medium 21 collects at the peripheral wall 11b of the rotor 11, as shown in Figures 1 and 2. The first chamber 13 is also separated by a partition wall 23 from a turbine chamber 25, in which the blade wheel 7 is positioned. Openings in the form of nozzles 27 are implemented within the partition wall 23. In the following, the mode of operation of the vapor turbine 1 will now be explained.

Combustion gases 29 of a heating device (not shown) are supplied to the rotor 11 on the front wall 11a positioned on the side facing toward the first chamber 13. As may be seen in Figure 1, the combustion gases 29 are supplied in such a way that they are guided along the rotor 11 from its axis of rotation radially outward. In this case, the first front wall 11a of the rotor 11 is heated by the combustion gases 29, because of which the working medium 21 located in area of the first chamber 13 is heated, which finally results in at least partial vaporization of the working medium 21 in the first chamber 13. The first chamber 13 thus acts as a vapor generation chamber. By regulating the heat supplied using control and/or regulation of the quantity of supplied combustion gas 29 and/or its temperature, the power output by the vapor turbine 1 and/or the speed thereof may be controlled and/or regulated.

In order to allow sufficient heat exchange between the combustion gases 29 and the interior of the first chamber 13 or vapor generation chamber, heat exchanger elements (not shown) are located on the first front wall 11a of the rotor 11 in area of the first chamber 13, preferably both on the side facing toward the combustion gases 29 and also on the side facing toward the first chamber 13, which the combustion gases 29 and/or the working medium 21 vaporized in the first chamber 13 flow through. In particular, the first front wall 11a of the rotor 11 comprises a material having high thermal conductivity.

The vaporized working medium 21 travels within the first chamber 13 from the peripheral wall 11b to the axis of rotation of the rotor 11. A countercurrent principle is thus implemented in the vapor turbine 1. This results in efficient exploitation of the energy of the combustion gases 29. The combustion gases 29 of higher temperature are incident on the area of the first chamber 13 facing toward the axis of rotation of the rotor 11, so that especially hot vapor arises in this area. The combustion gases 29 traveling in the radial direction of the rotor 11 then cool down again and bring to a boil the working medium 21 in area of the peripheral wall 11b of the rotor 11. Efficient exploitation of the thermal energy of the combustion gases 29 is thus achieved.

The working medium 21 heated in area of the peripheral wall 11b of the rotor 11 flows through the first chamber 13 and/or vapor generation chamber in the direction toward the partition wall 23, while expanding in an isobaric way. Therefore, an increased internal pressure arises within the first chamber 13, which is noticeable in that the level of the working medium 21 in the area of the first chamber 13 is lower than that in the second chamber 15. The vapor thus generated in the first chamber 13 flows through the nozzles 27 and is expanded adiabatically at the same time. As may be seen in Figure 2 in particular, the nozzles 27 are not oriented radially, but rather are inclined, so that an optimum angle of inclination of the nozzles 27 is settable. The vapor thus hits the blade wheel 7 in such a way that there is a recoil of the rotor 11 in relation to the stator 3, which generates and/or maintains a rotational movement of the rotor 11.

After the passage through the blade wheel 7, the vapor exits from the turbine chamber 25 into the second chamber 15, which is used as the condensation chamber. The vapor cools there and the working medium 21 therefore condenses out in the area of the second chamber 15.

Because of the rotation of the rotor 11, condensed working medium 21 collects on the peripheral wall 11b of the rotor 11. In order to achieve cooling of the vaporized working medium 21 in the second chamber 15, which acts as a condensation chamber, cooling air 31 is applied to the second front face 11c of the rotor 11. This supply is also performed in accordance with the countercurrent principle. Cold air flows as

cooling air from the outside of the rotor 11 in a radial direction toward the axis of rotation of the rotor 11. The cooling air 31 is heated at the same time. In contrast, the vaporized working medium 21, which flows radially away from the axis of rotation of the rotor 11 in the interior of the second chamber 15, is increasingly cooled and condensed in this case. Since therefore the already heated cooling air 31 may absorb further heat energy in area of the axis of rotation of the rotor 11, a conductive heat exchange between the working medium 21 and the cooling medium 31 being supported by structuring of the wall 11c (not shown), preferably in the form of heat exchanger elements, efficient heat dissipation from the second chamber 15 is ensured. The working medium 21 condensed in the second chamber 15 then flows through the openings 19 in the wall 17 into the first chamber 13, where it is again vaporized.

Because of the centrifugal force acting on the working medium 21, it is accelerated outward and therefore closes the openings 19, so that the vapor from the first chamber 13 may reach the second chamber 15 exclusively through the nozzles 27. Even in the event of a larger pressure in the first chamber 13 than the pressure in the second chamber 15, a secure closure of the openings 19 is ensured for the vapor of the working medium 21 generated in the first chamber 13, since the openings 19 are held closed by the working medium 21 because of the hydrostatic pressure caused by the centrifugal force.

In order to allow the vapor turbine 1 to start up automatically, check valves may be positioned within the openings 19. These cause vapor which is initially generated in the first chamber 13 to ensure rotation of the rotor 11 by exiting through nozzles 27, so that after beginning the rotation, closure of the openings 19 by the working medium 21 is ensured. In addition, closure devices, such as valves, may also be provided in the nozzles 27 in order to achieve control of the rotational velocity of the rotor 11. The valves in the openings 19 and the nozzles 27 may particularly be connected to a control and regulation device (not shown) in this case. Furthermore, speed control and/or regulation of the vapor turbine 1 is possible through variation of the quantity of heat energy supplied using the combustion gases 29 and/or through variation of the angle of inclination of the nozzles 27.

A second embodiment of a thermal combustion engine according to the present invention is shown in Figures 3 and 4 in the form of a vapor turbine 1', or rather a compact vapor turbine, having an integrated vapor generation zone. The vapor turbine 1' essentially corresponds in its basic construction to the construction of the vapor turbine 1 illustrated in Figures 1 and 2. In contrast to the vapor turbine 1, in the vapor turbine 1', the corresponding elements are provided with the identical reference numbers, but with an apostrophe. The vapor turbine 1' essentially differs from the vapor turbine 1 through a different flow guide of the vaporized and/or liquid working medium 21'.

Similar to the operation of the vapor turbine 1, combustion gases 29' are supplied to the rotor 11' of the vapor turbine 1' on the first wall 11a' positioned on the side facing toward the first chamber 13'. This supply is also performed, as may be inferred from Figure 3, in accordance with the countercurrent principle. Working medium 21' provided inside the first chamber 13' is heated by the combustion gases 29'. In contrast to the operation of the vapor turbine 1, this vaporized working medium 21' only flows through nozzles 27' into the turbine chamber 25' and/or the second chamber 15' after a deflection by nearly 180° using a flow guiding body 14'. This deflection around the flow guiding body 14' particularly offers the advantage that entrained droplets of the working medium 21' may not follow the vapor flow around the flow guiding body 14' and thus may not reach the turbine chamber 25' and/or the second chamber 15' via the nozzles 27'. The entrained droplets flow with the vapor flow in the direction of the axis of rotation of the rotor 11', but move further in the radial direction and hit the flow body 14', where they are accelerated in the direction of the peripheral wall 11b' because of the acting centrifugal force. Furthermore, due to the flow guiding body 14', the vaporized working medium 21' may flow up to the axis of rotation of the rotor 11' within the first chamber 13', and therefore maximum heat transfer of the energy of the combustion gases 29' to the working medium 21' may occur.

After deflection, the vaporized working medium 21' flows through nozzles 27' in the radial direction to the blade wheel 7'. The vaporized working medium 21' then flows within the second chamber 15' in proximity to the shaft 5' in the direction of the front wall 11c'. This flow guiding is particularly achieved by a flow guiding body 16'

positioned in the second chamber 15' in the area of the blade wheel 7'. This flow guiding ensures that the vaporized working medium 21' flows in accordance with the countercurrent principle in relation to the cooling air 31' on the inside of the front wall 11c' in the direction of the peripheral wall 11b'. In addition, the flow guiding within the vapor turbine 1' offers the advantage that, in comparison to the vapor turbine 1, a blade wheel 7' may be used which has a larger diameter than the blade wheel 7 of the vapor turbine 1. The vapor turbine 1' may therefore be operated at lower speeds.

The working medium 21' condensed in the second chamber 15' collects on the peripheral wall 11b' because of the rotational forces and flows through channels 20' back into the first chamber 13'. The channels 20' are formed in this case by the peripheral wall 11b' and a generally cylindrical partition wall 24', which particularly comprises the flow guiding bodies 14' and 16'. In this case, the partition wall 24' is implemented as thermally insulating particularly in the area of the channels 20' in order to avoid heating of the working medium 21' within the channels 20'.

A third embodiment of a thermal combustion engine according to the present invention is shown in Figures 5 and 6 in the form of a vapor turbine 1", or rather a compact vapor turbine. The vapor turbine 1" generally corresponds in its basic construction to the construction of the vapor turbine 1' illustrated in Figures 3 and 4. The elements of the vapor turbine 1" which correspond to those of the vapor turbine 1' have identical reference numbers. The vapor turbine 1" differs from the vapor turbine 1' generally in that a blade wheel 7" is provided, which is connected via at least one connection element 6" to a shaft 5" of the stator 3". As may be seen in Figure 6 in particular, the blade wheel 7" concentrically encloses a flow guiding wheel 8", which is connected via connection elements 18" to the wall 17" and therefore to the rotor 11", as may be seen from Figure 5 in particular.

As shown in Figure 6, the blade wheel 7" has blades 28", while the flow guiding wheel 8" comprises blades 30". Through this arrangement of the flow guiding wheel 8" in relation to the blade wheel 7", a further increase of the efficiency of the vapor turbine 1" is achieved in comparison to the vapor turbine 1'. The working medium 21' exiting out of the nozzles 27" first hits the blades 28" of the blade wheel 7", through which the rotor 11" is driven in relation to the stator 3" to which the blade wheel 7" is

connected. The working medium exiting out of the blade wheel 7" hits the blades 30" of the flow guiding wheel 8", which is connected to the rotor 11". Therefore, the remaining energy present in the working medium is also at least partially converted into movement energy of the rotor 11" by the flow guiding wheel 8".

The vapor turbines 1, 1', 1" illustrated in Figures 1 through 6 are single-stage radial turbines, since only one blade wheel 7, 7', 7" is provided in each case and, in addition, the vapor hits the blade wheels 7, 7', 7" in the radial direction. In contrast to this, a fourth embodiment of a thermal combustion engine according to the present invention is illustrated in Figure 7 in the form of the vapor turbine 51, or rather a multistage axial turbine, which is constructed as an impulse turbine, i.e., according to the Curtis principle.

Impulse turbines are understood as vapor turbines in which the intake and outlet pressure of the vapor of a working medium into and/or out of the running blades of a blade wheel are equal. Therefore, the blades of an impulse turbine are driven using the energy from the velocity reduction of the vapor in the running blades. In particular, the vapor turbine 51 has velocity stages, i.e., the velocity of the vapor is exploited in stages. In order to achieve higher thermodynamic efficiency, it is also provided in impulse turbines of this type that pressure stages are generated, i.e., a pressure gradient is divided into multiple stages. This offers the advantage that vapor velocities which are too large may be avoided.

The vapor turbine 51 has a stator 53 which surrounds a shaft 55. Blade wheels 57a and 57b are positioned spaced apart from one another on the shaft 55. A rotor 61 is provided in the vapor turbine 51 so it is rotatable in relation to the stator 53 via a bearing 59 and seals 60. The rotor 61 has a first front wall 61a, a peripheral wall 61b, and a second front wall 61c. Furthermore, a first chamber 63, which is used as a vapor generation chamber, and a second chamber 65, which is used as a condensation chamber, are implemented inside the rotor 61. In addition, the vapor turbine 51, in contrast to the vapor turbine 1, has an equalizing chamber 67 for collecting liquid working medium 73. The first chamber 63 and the equalizing chamber 67 are separated from one another via a thermally insulating wall 69.

Similar to the operation of the vapor turbines 1, 1', 1", in the vapor turbine 51, combustion gases 71 are supplied to the first front wall 61a of the rotor 61 in accordance with the countercurrent principle. At least a part of the working medium 73 is thus vaporized within the first chamber 63. The working medium 73 thus vaporized is firstly supplied via lines 75, at the ends of which nozzles 77 are positioned, to the first blade wheel 57a. Because of the expansion of the vapor in the area of the nozzle 77 and the incidence of the vapor on the first blade wheel 57a, there is a rotational movement of the rotor 61.

In order to be able to completely exploit the energy residing in the vaporized working medium, in the vapor turbine 51, the vapor directed axially to the first blade wheel 57a enters a deflection wheel 79a, which rotates together with the rotor 61, after the passage through the blade wheel 57a. This deflection wheel particularly acts as a running wheel and converts the energy residing in the vapor into work energy. Furthermore, the vapor flow is deflected in the deflection wheel 79a before this flow is incident on a second blade wheel 57b, which is also connected to the shaft 55, again generally in the axial direction in relation to the axis of rotation of the rotor 61.

After passing through the second blade wheel 57b, the vapor reaches a second deflection wheel 79b, also particularly used as a running wheel, which is also connected to the rotor 61. The vapor then enters the second chamber 65, where it is cooled and condensed because of the cooling of the second front wall 61c of the rotor 61 using cooling air 81. The condensed working medium 73 than then flows out of the second chamber 65 via the equalization chamber 67 into the first chamber 63. In this case, the working medium 73 flows through channels 83 which are implemented between the peripheral wall 61b and a generally cylindrical partition wall 85. The partition wall 85 is used for thermal insulation of the area in which the blade wheels 57a, 57b and the deflection wheels 79a, 79b are located and, in addition, the peripheral wall 61b and/or the channels 83. For this purpose, the partition wall 85 has a generally low thermal conductivity. In particular, the partition wall 85 may be implemented as hollow, and may particularly comprise an insulation material.

A fifth embodiment of a thermal combustion engine according to the present invention is illustrated in Figure 8a in the form of a multistage vapor turbine 51'. The

basic construction of the vapor turbine 51' generally corresponds to that of the vapor turbine 51 illustrated in Figure 7. Therefore, essentially identical components of the vapor turbine 51' have identical reference numbers as those of the vapor turbine 51, but with an apostrophe.

In contrast to the vapor turbine 51, the vapor turbine 51' has three blade wheels 57a', 57b', and 57c'. Accordingly, the vapor turbine 51' also has three deflection wheels 79a', 79b', and 79c', which are each connected to the rotor 61'. Furthermore, the vapor turbine 51' differs from the vapor turbine 51 in that, because of the geometry of the nozzle 77', the blade wheels 57a', 57b', 57c', and deflection wheel 79a', 79b', and 79c', it is a reaction turbine.

Since the vapor flows through the blade wheels 57a', 57b', 57c' at an inclined angle in relation to the axis of rotation of the rotor 61', the vapor turbine 51' is additionally a diagonal turbine. The construction as a reaction turbine means that the vapor exits out of the nozzle 77' at a relatively high pressure, and the vapor pressure is reduced in the blades of the blade wheels 57a', 57b', and 57c'. Therefore, there is an energy conversion of the vapor in the blades of the blade wheels 57a', 57b', 57c', which is composed of the velocity conversion of the vapor and, in addition, the back pressure occurring upon relaxation of the vapor. Therefore, multiple pressure stages are implemented within the vapor turbine 51', which have a low staged pressure gradient and therefore achieve a favorable flow design and a good dynamic efficiency.

Furthermore, an alteration of the vapor turbine 51' illustrated in Figure 8a is shown in Figure 8b in the form of the vapor turbine 51". The basic construction of the vapor turbine 51" generally corresponds to that of the vapor turbine 51' and identical elements of the vapor turbine 51" in comparison to the vapor turbine 51' have identical reference numbers. The vapor turbine 51" generally differs from the vapor turbine 51' through a different geometric design of the blade wheels 57a", 57b", 57c", the deflection wheels 79a", 79b", and 79c", and the partition wall 85". The blade wheels 57a", 57b", 57c" each differ from one another through different diameters.

In addition, the geometry of the blades of the blade wheels 57a", 57b", 57c" differs to produce velocity and/or pressure stages within the vapor turbine 51".

Correspondingly, the shape of the partition wall 85" and the shape of the second chamber 65" are adapted to these different diameters. In addition, the lines 75" and the nozzles 77" are also adapted to the different geometry of the blade wheel 57a" in comparison to the vapor turbine 51'. Finally, the deflection wheels 79a", 79b", and 79c" are implemented in such a way that the blades which they comprise guide the working medium 73" flowing through the blade wheels 57a", 57b", 57c" diagonally in relation to the axis of rotation of the rotor 61".

The embodiments of a thermal combustion engine according to the present invention illustrated in Figures 1 through 8b are jointly distinguished in that the rotor generally completely surrounds the vapor generation device in the form of the chambers 13, 13', 63, 63' and the condensation device in the form of the chambers 15, 15', 65, 65'. Embodiments according to the present invention of a thermal combustion engine will now be described on the basis of Figures 9 through 11, in which the vapor generation device and/or the condensation device is generally completely and/or partially surrounded by the stator. These thermal combustion engines also have the advantages that they have a relatively low power to weight ratio, a high efficiency, low pollutant and noise emissions, and a simple, low-maintenance, and low-wear construction. In particular, these thermal combustion engines, which are constructed as external rotor motors, also have the advantage that the centrifugal force causes a centrifugal force closure to be implemented between the condenser and the vaporizer, so that additional feed pumps may be dispensed with.

A sixth embodiment of a thermal combustion engine is illustrated in Figure 9 in the form of a vapor turbine 101, or rather a compact vapor turbine, having an integrated vapor generation zone. The construction of the vapor turbine 101 is similar to that of the vapor turbine 1" illustrated in Figures 5 and 6. Thus, the vapor turbine 101 comprises a stator 103, which in turn comprises a fixed shaft 105.

In contrast to the embodiments according to the present invention illustrated in Figures 1 through 8a, a front wall 107 of the vapor turbine 101 is connected to the shaft 105, and thus forms a part of the stator 103. Furthermore, the shaft 105 is connected via the front wall 107 to a first blade wheel 109 and a second blade wheel 111. In contrast, a peripheral wall 113 and a front wall 115 are mounted so they are

rotatable in relation to the stator 103. These walls 113, 115 thus form a rotor 117. Furthermore, partition walls 119, 121, and 123 are connected to the rotor for secure rotational driving.

Furthermore, a flow guiding wheel 125 is positioned on the partition wall 121. This flow guiding wheel 125 is mounted so that it is rotatable on the shaft 105 via a bearing 127. However, mounting the flow guiding wheel 125 on the shaft 105 is not absolutely necessary. In particular, the rotor 117 may be mounted sufficiently via the sealing devices 133, so that the bearing 127 may be dispensed with.

The interior of the vapor turbine 101 is subdivided using the preferably thermally insulating wall 121 into a first chamber 129 and a second chamber 131. In this case, the first chamber 129 acts as a vapor generation chamber, while the second chamber 131 acts as a condensation chamber. The second chamber 131 is sealed in the area of the transition of the front wall 107 to the peripheral wall 113 by a sealing device 133. The sealing device 133 may be implemented in a form generally known to those skilled in the art. Thus, the sealing device 133 may particularly comprise sealing elements, in the form of O-rings and/or a labyrinth system, for example. However, it is important for the mode of operation of the vapor turbine 101 that the sealing device 133 ensures a seal of the second chamber 131 and simultaneously allows a rotation of the rotor 117 in relation to the stator 103. Therefore, in the vapor turbine 101, the vapor generation device in the form of the first chamber 129 is generally completely surrounded by the rotor 117, while the condensation device in the form of the second chamber 131 having the front wall 107 is generally completely surrounded by the stator 103.

In the following, the mode of operation of the vapor turbine 101 will be explained. Similar to the embodiments described above, combustion gases 135 are incident on the front wall 115 in accordance with the countercurrent principle. This causes heating of the first chamber 129, which results in a working medium 137 being vaporized. The working medium 137 enters the second chamber 131 between the partition walls 121, 123 and through the nozzles 139. The vaporized working medium hits the first blade wheel 109 there, which results in driving of the rotor 117 in relation to the stator 103.

After passing through the first blade wheel 109 connected to the stator 103, the vaporized working medium hits the flow guiding wheel 125 connected to the rotor 117, through which the rotor 117 is driven further. After exiting the flow guiding wheel 125, the working medium finally at least partially hits the second blade wheel 111 connected to the stator 103 via the front wall 107. In order to achieve condensation of the working medium in the area of the second chamber 131, cooling air 141 flows along the side of the front wall 107 facing away from the chamber 131 in accordance with the countercurrent principle.

The condensed working medium collects in the area of the peripheral wall 113 because of the rotational movement of the rotor 117, dog elements, preferably in the form of blades, being positioned in the area between the front wall 107 and the partition wall 119, which rotate together with the rotor 117, and are particularly attached thereto. These dog elements are not absolutely necessary, however, but elevate the operational reliability of the centrifugal force closure by the working medium 137.

The working medium 137 then flows back into the first chamber 129 between peripheral wall 113 and partition wall 119. The working medium 137 also ensures in the vapor turbine 101 that a closure is achieved between the first chamber 129 and the second chamber 131 in the area of the partition wall 119 and the peripheral wall 113, so that the working medium 137 must always go from the first chamber 129 into the second chamber 131 by the path via the nozzle 139. The vapor turbine 101 offers the advantage that the front wall 107 does not execute a rotational movement, because of which there is particularly laminar flow of the cooling air 141 along the front wall 107. Therefore, the efficiency of the condensation device in the form of the second chamber 131, and thus the efficiency of the vapor turbine 101, are increased.

Furthermore, this construction of the vapor turbine 101 makes the supply of a cooling medium into the front wall 107 easier. Thus, the front wall 107 may be permeated by flow devices (not shown) in the form of channels. These channels may particularly be part of a closed cooling loop, in which a cooling fluid, such as water, is circulated. Because the front wall 107 is connected to the shaft 105 of the stator 103, this cooling

medium may be supplied through a channel positioned on the shaft 105 or permeating the shaft. Through this further cooling possibility, the efficiency of the vapor turbine 101 may be increased further.

A seventh embodiment of a thermal combustion engine according to the present invention is illustrated in Figure 10 in the form of a vapor turbine 101', or rather a compact vapor turbine, having an integrated vapor generation zone. The construction of the vapor turbine 101' generally corresponds to that of the vapor turbine 101, which is illustrated in Figure 9. In particular, the vapor turbine 101' may have the dog devices in the area of the partition wall 119 and the front wall 107 described in regard to the vapor turbine 101. Elements of the vapor turbine 101' identical to the vapor turbine 101 have identical reference numbers, while different elements are provided with identical reference numbers and a single apostrophe.

The construction of the vapor turbine 101' generally differs from the construction of the vapor turbine 101 in that both the condensation device and also the vapor generation device are generally completely surrounded by a stator 103'. The stator 103' comprises a shaft 105' which is connected to both the front wall 107 and also a front wall 115'. The front wall 115' is therefore not surrounded by the rotor 117'. The rotor 117' generally comprises the peripheral wall 113' which is connected to the partition walls 119, 121, 123. Furthermore, the flow guiding wheel 125 is attached to the partition wall 123.

To seal the first chamber 129', which is used as the vapor generation device, the peripheral wall 113' is connected via sealing device 143' to the front wall 115'. Through this construction of the vapor turbine 101', in addition to the front wall 107, the front wall 115' also remains fixed during operation of the vapor turbine 101'. The efficiency of the vapor generation device 129' is thus increased, since the combustion gases 135 supplied to the front wall 115' are not eddied. Therefore, better heat exchange with the first chamber 129' is achieved and thus the efficiency of the entire vapor turbine 101' is further increased.

A further increase of the efficiency of the vapor turbine 101' may be achieved in that the front wall 115' ~~has~~ may have a further flow device in the form of channels

permeating the front wall 115', through which a heating medium, preferably supplied via the shaft 105', is circulated. Flow devices in the form of channels may be provided in the front wall 107 analogously as described previously on the basis of the vapor turbine 101.

Finally, an eighth embodiment of a thermal combustion engine according to the present invention in the form of a vapor turbine 101" is illustrated in Figure 11. The construction of the vapor turbine 101" is comparable to that of the vapor turbine 101' illustrated in Figure 10. Identical elements of the vapor turbine 101" have identical reference numbers as the elements of the vapor turbine 101', while differing elements have identical reference numbers, but with a double apostrophe.

The two vapor turbines 101' and 101" differ from one another essentially in that the front walls 107" and 115" are generally implemented in two parts. Thus, the front wall 107" comprises the parts 107a" and 107b". In this case, the front wall part 107b" is connected to the shaft 105", while the front wall part 107a" is connected to the peripheral wall 113". This offers the advantage that the sealing devices 133" are not positioned in the area of the working medium 137, and a seal may thus be achieved more easily.

Analogously, the front wall 115" is implemented in two parts, in the form of the first front wall part 115a" and the second front wall part 115b". The front wall part 115a" is connected to the peripheral wall 113", while the front wall part 115b" is connected to the shaft 105". Because of this construction, both the first chamber 129", having the front wall 115", which is used as the vapor generation device, and also the second chamber 131", having the front wall 107", which is used as the condensation device, are surrounded partially by both the rotor 117" and also the stator 103".

In further embodiments of the present invention (not shown), the vaporized working medium exiting out of the first chamber may first hit the blade wheel(s), with a flow guiding wheel operationally linked to the rotor interposed. Particularly if a single blade wheel is used to exploit the energy residing in the vaporized working medium, a flow guiding wheel operationally linked to the rotor, which particularly acts as a blade wheel, may be downstream from this blade wheel. In addition, the arrangement of the

deflection wheel, the flow guiding wheel, and/or the blade wheel is not restricted to an axial arrangement in relation to one another. In order to implement high compactness of the thermal combustion engine of the present invention, these wheels may particularly be positioned at least partially radially in relation to one another.

In further embodiments of the present invention (not shown), the thermal combustion engine may be implemented in the form of back pressure turbines and/or extraction turbines, in which vapor generated through additional extraction devices in the vapor generation chambers may be taken from the vapor turbines.

A use of the thermal combustion engine according to the present invention in the form of a topping and/or exhaust vapor turbine may also be performed, in that additional vapor may be supplied to the thermal combustion engine externally, in addition to the vapor generated within the thermal combustion engine.

In regard to the exemplary embodiments of the present invention described above, it is to be noted that, as may be seen in particular on the basis of the vapor turbine 1' illustrated in Figures 3 and 4, the working medium may have a flow course within the thermal combustion engine that is tailored to the particular requirements of the thermal combustion engine. Thus, it is possible in particular that the working medium may flow axially, radially, or even transversely in sections, particularly both radially toward an axis of the thermal combustion engine and also away from this axis. The present invention is thus particularly not restricted to the flow paths of the working medium illustrated as examples.

The features of the present invention disclosed in the above description, in the figures, and in the claims are exemplary only and may be used to implement the present invention in various embodiments both individually and in any arbitrary combination.

What is claimed is: